International Journal of Civil Engineering and Technology (IJCIET)
Volume 8, Issue 3, March 2017, pp. 01–10 Article ID: IJCIET_08_03_001
Available online at http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=3
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

IDENTIFICATION OF GROUNDWATER POTENTIAL ZONES USING REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM

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ABSTRACT

The objective of the study area is to identify the groundwater potential zones using RS and GIS software 9.3. The various thematic maps are Boundary, Drainage, DEM, Drainage Density, Slope, Soil, Lineaments, Land Use/ Land Cover, Rainfall maps. The Digital Elevation Model (DEM) has been generated from the 20 m contour interval contour lines derived from SOI toposheets. The Slope map has been prepared from DEM. These maps have been overlaid in terms of weighed overlay method using Spatial Analysis tool in Arc GIS 9.3. During weighed overlay analysis, the ranking has been given for each individual parameter of each thematic map and weights were assigned according to their influence for Soil (40%), Land use/Land cover (25%), drainage density (10%), rainfall (10%), lineaments (5%) and Slope (10%). The resulting maps presents the ground water potential zones in terms of Very Good (3.91 Km^2), Good (22.27 Km^2), Fair (25.65 Km^2), Moderate (22.31 Km^2) and Poor zones (1.23 Km^2). The result depicts the groundwater potential zones in the study area and found to be helpful in better planning and management of groundwater resources.

Key words: GIS software, ground water potential zones, remote sensing.

Cite this Article: Y. Yaswanth Kumar, D.V. Satyanarayana Moorthy and G. Shanmuka Srinivas, Identification of Groundwater Potential Zones Using Remote Sensing and Geographical Information System. *International Journal of Civil Engineering and Technology*, 8(3), 2017, pp. 01–10.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=3

1. INTRODUCTION

Ground water, a fresh water resource, is stored in aquifer, which are recharged by atmospheric precipitation, which seeps into the ground or as the surface water drains into it. In many regions recharge areas are near the surface and may be significantly affected by agriculture, residential or industrial activity. Once the refuse of such activities contaminates groundwater, it become difficult and sometimes impossible to restore it to its original quality. To meet the increasing water demands, reliance on ground water has been rapidly increasing, especially in the arid and semiarid regions. Ground water has excellent natural quality, which is generally adequate for potable supply which little or no treatment. It is an attraction as a supply potion because it is often conveniently available close to where water is required. Groundwater has been the main source for supplying water to the society. For instance, groundwater withdrawals in some of the developed countries account for the 5th of the total water use. Moreover groundwater is a vital source of water supply in areas where dry summers of extended droughts cause stream flow to reduce. Through it is important for groundwater it should not play down the role of surface water. On the contrary, many surface streams receive a major portion of their flow from groundwater through interflow.

Groundwater exploration involves knowledge of hydrological properties of various geological materials such porosity, permeability, storage coefficient, transmissivity, and specific yield, or in other words holding and discharge capabilities of geological materials. Relationship between various landforms, climates and their effect on weathering on geological materials and subsequently on groundwater occurrence and its equally important. It also involves knowledge of various types of geological structures present in underlying geological materials and their role in storage and movement of groundwater. Knowledge about recharge and discharge areas are another very important aspect. One more essential information in ground water exploration is the relationship between drainage network in an area and hydrological properties of rocks. Groundwater holding capacity of rocks depends on compactness of rocks. Compactness in turn depends on presence of pore spaces within rocks (porosity) and their interconnectedness (permeability) which is enhanced by presence of weak planes (fractures, joints, rock contacts, shear zones) and weathering of rocks. Groundwater movement within rocks and sediments is controlled by permeability of rocks and geological structures.

A ground water system comprises the surface water, the geological media containing the water (such as aquifer), flow boundaries and sources (such as recharge) and sinks (such as withdrawals). Aquifers are rocks of sediment that act storage reservoirs for groundwater and typically characterized by high porosity and permeability. An aquiclude is rock or sediment that represents a barrier to groundwater flow. Infiltered water into open aquifers from top represents recharge. Pumping, evapotranspiration and loss through boundaries represent withdrawal. Open aquifers contain a saturated zone. Water enters closed aquifers from recharge area.

2. REVIEW OF LITERATURE

Ahmad et al., (2005) (1) discussed a new technique to estimate net groundwater use across large irrigated areas by combining Remote Sensing and water balance approaches in Rechna Doab located in the Indus basin irrigation system of Pakistan. Records climatic data, canal discharges at major off takes, phreatic surface depth fluctuations, and simplified information on soil textural properties were used as input data into Geographic Information System and Remote Sensing tools. With this approach, groundwater recharge will not be quantified explicitly, but is a part of net groundwater use and the spatial variation can be quantitatively described.

Ashim Das Gupta (1996) (2) proposed that evaluation of long-term natural recharge based on water balance method combined with the evaluation of dynamic response of aquifer system provides an appropriate tool for assessing the long term sustainable yield of the groundwater system. This approach has been elaborated with reference to two case studies: one for the groundwater basin in the Kathmandu Valley of Nepal and the other for the coastal aquifer of Mannar Island in Sri Lanka.

Kamaraju et al., (1995) (3) evaluated groundwater potential of West Godavari district, Andhra Pradesh state, India. Information on the parameters controlling groundwater such as lithology, geomorphology, structure and recharge condition of the study area was analyzed using Arc Info GIS software. An evaluation of groundwater potential and generation of a map showing three major hydro geological conditions with distinct groundwater prospects which would serve as a basic tool in the exploitation of groundwater resources of the district was presented.

Naik and **Awasthi** (2003) (4) made groundwater resources assessment of the lower Koyna river basin in India. Regional specific yield and groundwater recharge have been estimated on the basis of water table fluctuation method.

Reddy (2002) (5) evolved a suitable methodology to quantify the groundwater recharge by a systematic study of precipitation data of the basin along with the draft from the Saligeru basin in Andhra Pradesh. Water table fluctuation data from observation wells for the past years were collected and analyzed for groundwater recharge. It was observed that the wells located at higher elevations were subjected to maximum magnitude of groundwater fluctuations.

Sophocleous (1991) (6) estimated natural groundwater recharge by combining the soil water balance and water-level fluctuation methods and named it as 'Hybrid water-fluctuation method'. Major uncertainties in the water balance and groundwater fluctuation analysis approaches were outlined and a combination methodology for reducing some of the uncertainties was proposed. Based on field-measured data from Kansas showed that the proposed methodology gave better and more reliable results than either of the two approaches when used in single.

Sameena et al., (2005) (7) made an attempt to assess the groundwater balance using the water table fluctuation method in which all the components in the water balance equation were known and the only component which was considered unknown was the rainfall recharge. Most of the inputs were derived from the satellite Remote Sensing data. This method though tedious gave reliable and accurate results compared to the other methods.

Saraf and **Jain** (1996) (8) demonstrated integrated use of Remote Sensing and GIS methods for groundwater exploration in parts of Lalitpur District, U.P. Various sets of information layers such as geological, soil, topographical and groundwater information have been applied along with IRS-1A LISS-I data for groundwater exploration. Groundwater recharge map was produced with the help of groundwater level data and specific yield information of different rock formations.

Sharma (2002) (9) reviewed various models available to represent different recharge processes. Most of these models were applicable at a micro level. He emphasized the urgent need to develop models for estimation of groundwater recharge from different source namely rainfall, canal systems and return flow from irrigated fields for application at the regional level.

Shiv Kumar et al., (2004) (10) carried out analysis of groundwater data for the assessment of groundwater behavior, its potential and water table trend in Bareilly district of

Uttar Pradesh. The water table trend was studied and groundwater inventory was prepared to observe the stage of ground water development.

Venkateswara Rao (1994) (11) proposed an improved methodology for identification of groundwater potential zones in a typical khondalitic terrain. It involved assigning numerical weights and ratings to various geophysical and geomorphic parameters leading to computation of Groundwater Potential Index (GWPI) of a given site. It was found that the GWPI of any site should be 35 and above in order to have 75% success rate of wells with an yield norm of 8000 liters per hour per well.

3. STUDY AREA

The Swarnamuki basin is situated northern latitudes 13° 25' 30" to 14° 28' 30" and eastern longitude 79° 08' 39" to 80° 11' in Chittoor and Nellore District of A.P, India Fig (1). The Swarnamuki basin covers area in Andhra Pradesh over 3225 Sq. Km. The total length of Swarnamuki basin is 130 Km. It originates at the Chandragiri Mandal of Chittoor District, and flows throughNellore district in a North-East direction and finally joins Bay of Bengal. In present study, the Konakaluva sub-basin is taken to determine the groundwater prospect zones. The Konakaluva sub-basin lies between north latitude13^0 $30^{'}$to $13^0 45^{'}$ and eastern longitude $79^0$30'to $79^0 45^{'}$ with a total drainage of 75.37km^2.

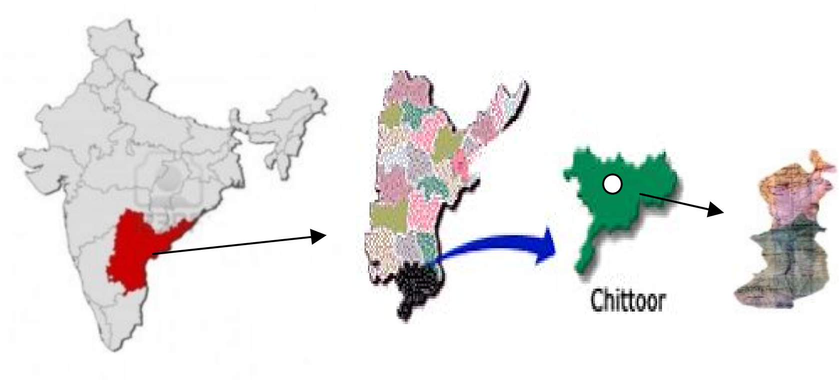


Figure 1 Location of Study Area

3.1. Details of Data Collected

Following data were collected from various organizations for the present study

- Land Sat LISS-3 data acquired on 2011 geo coded at the scale of 1:50000 from NRSA, Hyderabad.
- Toposheets No.57 O/10 at the scale of 1:50000 from the Survey of India, Hyderabad.
- District geology map was collected at the scale of 1:50000 from the Geological Survey of India, Hyderabad.
- Rainfall data was collected from metrological department, Chittoor.
- Ground water level data was collected from Groundwater Department, Chittoor.
- Soil data has been collected from Agriculture Department, Tirupati.

4. METHODOLOGY

Integrated remote sensing and GIS based approach is a powerful tool for assessing groundwater potential zones based on which suitable locations for ground water withdrawals could be identified. Methodology for preparing ground water potential zones map in the study area is presented. It involves in the following steps.

- Integrated thematic maps such as base, drainage, geology, slope, soil and land use/ land cover overlays shall be prepared from Survey of India toposheets and satellite data respectively, by using remote sensing and GIS technique. The complete process of groundwater potential zone is in fig 2
- Field visits have been carried out for checking the interpretation and for collecting the additional information.
- Thematic maps have been prepared using Arc GIS Software.
- Field observations have been incorporated in various thematic maps.
- Multi-Criterion Evaluation technique have been used for assigning weightages, ranks and scores to various themes and features class by assessing the importance of it in ground water occurrence.
- After assigning the weightages, ranks and scores to the themes and features, all the themes have converted to raster format using 'Spatial Analysis', extension of ArcGIS software. The weights assigned to different theams presented in Table 1

Integrated groundwater potential zones map have been wide range of scores. This map shall be reclassified in thee GIS environment using Arc GIS software to demarcate various ground water potential zones in the study area based on certain decision rules. The generated output shall consist of various classes of ground water potential zones namely Good, Moderate and Poor Zones from ground water potential point of view.

In the project the ranking are given very good, good, fair, moderate, poor groundwater potential. Score of feature class for a theme is equal to product of weightages and rank.

"Raster Calculator" option of 'Spatial Analysist' extension of Arc Info Arc GIS software was used to prepare integrated groundwater potential zones map by adopting suitable map algebra.

The map algebra used in the "Raster Calculator" is given by table (1)

Groundwater potential zones= (Soil) X 0.40 + (Land Use/Land Cover) X 0.25 + (Lineaments) X 0.05 + (Drainage Density) X 0.10 +

(Slope) X 0.10+ (Rainfall) X 0.10

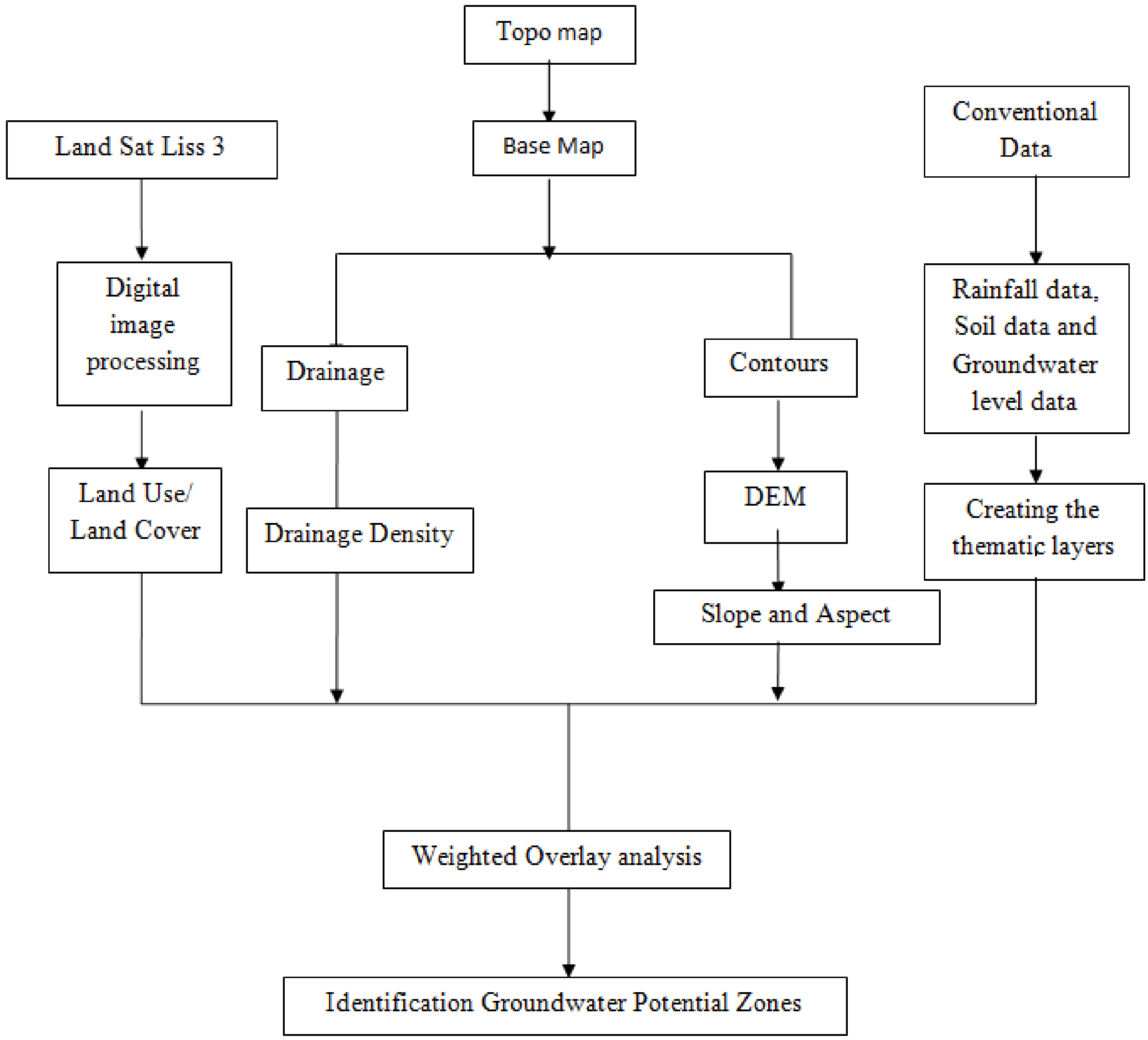


Figure 2 Flow chart for the groundwater potential zones using GIS technique

Table 1 Assigned and normalized for the individual features of the six different themes for ground water potential zoning in Konakaluva Basin

S. No.	Themes	Weightages	Feature Class	Ranks	Score
1	Soil	40	Loamy Clayey Soil Red sandy Soil Sandy Soil with coarse silt	1 4 3	85 125 110
2	Land Use/ Land Cover	25	Forest Waste Land Water Bodies Agriculture Build-Up-Area	4 3 1 2 1	105 75 20 45 20
3	Lineaments	5	----	----	-----
4	Drainage Density	10	Very low (0-2%) Low (2-15%) Moderate (15-22%) High (22- 40%)	4 3 2 1	40 30 20 10

			Very High (40-42.36%)	1	10
5	Slope	10	Nearly Level (0-8%) Gentle Slope (8-15%) Moderate Slope (15-45%) Steep Slope >45%	4 3 2 1	40 30 20 10
6	Rainfall	10	Low Moderate High	1 3 4	20 25 35

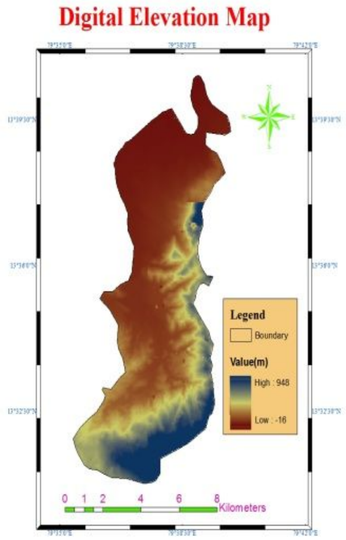
5. RESULTS AND DISCUSSIONS

The main objective of this project is to use GIS and Remote sensing techniques for the assessment, evaluation and analysis of spatial distribution of ground water potential zones in the Konakaluva sub Basin of Swarnamuki River. Ground water potential zone map have been prepared using eight thematic maps from satellites images, using data

The following conclusions are drawn:

- Contour and DEM maps Fig 3 have been developed in GIS environment. The basin is having varied surface elevations.
- Slope map Fig 7 was prepared from the DEM map. Slopes of the study area were found to vary between 0 to 40%.
- Three different types of soils are present in the study area, with a coverage percentage of Red sandy soil (40.71%), Loamy clayey soil (29.36%), and Sandy soil with silt (20.92%) Fig 10.
- In these soils, Red sandy soils are having more infiltration rate and loamy clayey soil are having low infiltration rate according to the soil conservation system (SCS TR-6) report.
- Study area has been classified for Land Use / Land Cover into five classes viz., Water bodies (2.29 sq km), Crop land (13.40 sq km), build-up-area(0.55sq km), Fallow land (20.44 sq km) and Forest (62.65sq km) based on Normalized Difference Vegetation Index (NDVI) report Fig 8.
- The drainage density map shows the network of the steams in the sub-basin Fig 6.
- Drainage density is an inverse function of permeability. The less permeable a rock is, the less infiltration of rainfall, which conversely tend to be concentrated in surface runoff.
- This gives origin to well developed and fine drainage system
- The surface conditions of the basin can be ascertained, from the Morphometric analysis. These in turn influence the recharge potential of the basin.

These maps have been overlaid in terms of weighed overlay method using Spatial Analysis tool in Arc GIS 9.3 version. During weighed overlay analysis, the ranking has been given for each individual parameter of each thematic map and weights were assigned according to their influence for Soil (40%), Land use/Land cover (25%), drainage density (10%), rainfall (10%), lineaments (5%) and Slope (10%).The resulting maps presents the ground water potential zones in terms of Very Good (3.91 Km^2), Good (22.27 Km^2), Fair (25.65 Km^2), Moderate (22.31 Km^2) and Poor zones (1.23 Km^2) . After overlay all these maps we have obatained the ground water potential zone map Fig 12.



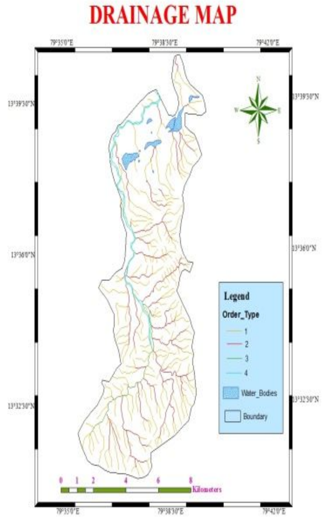
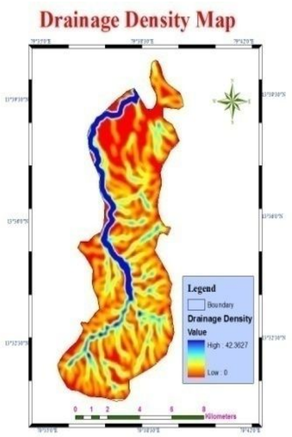
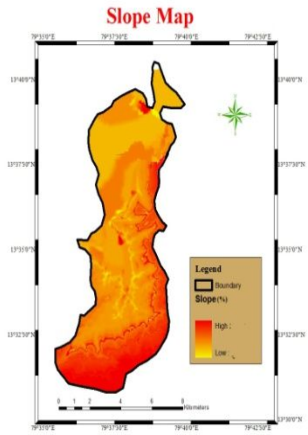


Figure 3 DEM Map **Figure 4** Land Sat LISS III **Figure 5** Drainage Map





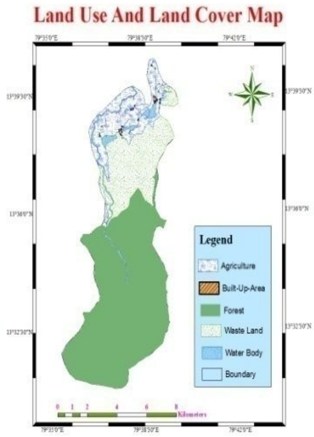
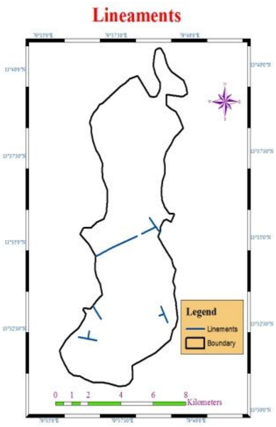
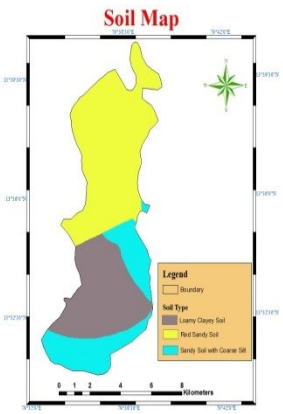


Figure 6 Drainage Density Map **Figure 7** Slope Map **Figure 8** Land use and land cover





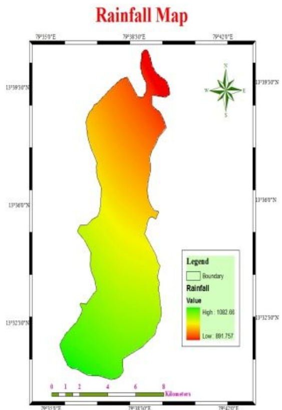


Figure 9 Lineaments Map **Figure 10** Soil Map **Figure 11** Rainfall Map

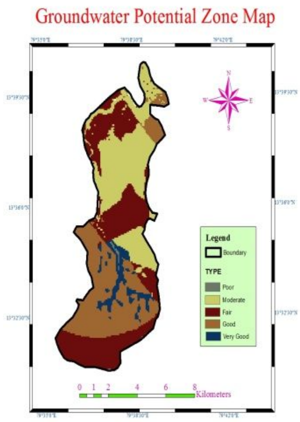


Figure 12 Groundwater potential zone Map

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